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ABSTRACT

This curriculum is intended to serve as a guide for high school instructors teaching a basic course on emission control systems on General Motors, Ford, and Chrysler products. The material may also be incorporated on an engine system basis and inserted into an overall tune-up curriculum. Other uses of the curriculum include specialized training for out-of-school youth and adults who wish to upgrade their skills or to enter this field. Curriculum content is divided into eight areas: air pollution, positive crankcase ventilation system, thermostatic air cleaners, air injection reaction (air system), exhaust gas recirculation system, spark control system, catalytic converter systems, and carburetor adjusting procedures. Informative material and some visual aids/diagrams are provided for topics covered in each of the eight areas. Appendixes include definitions of terms, a list of motor vehicle emissions control manufacturers' abbreviations, sources for manufacturer's emissions control manuals, and a list of public information materials. (YLB)

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SPECIAL AUTOMOTIVE REPAIR SERVICE CURRICULUM FOR GRADES 9 - 12

VEHICLE EMISSION SYSTEMS

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JUNE 23, 1982

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PREFACE

VEHICLE EMISSION SYSTEMS

The purpose of this outline is to serve as a guide to the instructor teaching high school students a basic course on Emission Control Systems. This course may be taught as a complete unit or it may be incorporated on an Engine System basis and plugged into an overall tune-up curriculum. Although there are many different types of Emission Control Systems, this outline will deal with those systems which are germane to most automobiles. It is advised that the student first understand basic concepts of the gasoline internal combustion engine operation before teaching this course as a unit.

ACKNOWLEDGMENTS

This is to acknowledge the outstanding efforts of Ralph Catalano for contributing his expertise in the development of this curriculum. We also wish to acknowledge the spirit and cooperation and contribution of Colorado State University and numerous automobile manufacturers who provided necessary information and manuals to be used in the development of this project. We also acknowledge Kathleen Gubbins for correlating the materials and typing of this document.

A special note of acknowledgment is given to Edward Shia, Consultant, State Department of Education, Trade and Industrial Education for his continual aid and guidance.

CONTENTS

Preface..... i

Acknowledgements.....ii

Abstract..... 1

Automotive Emissions That Require Control..... 5

Positive Crankcase Ventilation System.(PCV)..... 8

Thermostatic AirCleaner (TAC)..... 12

Air Injection System (AIR)..... 15

Evaporative Emissions System 18

Exhaust Gas Recirculation System (EGR)..... 21

Spark Control..... 25

Catalytic Converter System..... 29

Two and Four Gas Emission Analyzers..... 37

Adjustment Procedure Using - 4 Gas Analyzer..... 42

Job Operations..... 44

Definition of Terms..... 46

Appendices

Appendix I..... 1

Appendix II.....A-1

Appendix III.....B-1

ABSTRACT

The objective of this project was to develop a special automotive repair service curriculum for grades 9 - 12 to teach students in emission control systems on General Motors, Ford and Chrysler products.

Gubbins Associates coordinated the development of this curriculum utilizing the combined expertise of the vocational educators of the Connecticut Association for Trade and Industrial Educators. The effort of Gubbins Associates was to direct the energies and knowledge of these experts in the direction of developing an up-to-date curriculum which will meet the present and future needs of students enrolled in the vocational education programs in local school districts. Students should be able to use this material and training to enter and to advance themselves in an automotive repair career.

Gubbins Associates continually interacted with the State Department of Education Consultant for Trade and Industrial Education to assure the curriculum developed will meet the goals desired.

In developing the curriculum, Gubbins Associates worked toward the updating of training to meet the growing demand presently anticipated in the future for the testing of all motor vehicles which will be required under state statutes. These objectives were met by coordinating of all involved in the development of the curriculum and program. This was accomplished through meetings, use of telephone communication and personal visits. The director of this program was in constant touch with the consultant of the State Department of Education for Trade and Industrial Education.

GENERAL DESIGN

The curriculum includes a design for related instruction as well as laboratory/ shop instructional programs. The instructor, using this new curriculum will

more adequately meet the training needs of the student wishing to enter and be successful in a career of automotive.

This curriculum will not only be a supplement to existing automotive training programs in local educational agencies but can be provided to specialized training for out-of-school youth and adults who wish to upgrade their skills in the automotive business or others who wish to enter this field.

PROBLEM

As the new emission law goes into effect, garages throughout the state will be in need of employees knowledgable in this new area of automotive repair and inspection. This new curriculum will aid automotive repair instructors to update their skills in preparing students for entrance to this new job market.

EVALUATION

Throughout the development of this curriculum, the program was under the supervision of the consultant for Trade and Industrial Education. In addition, all of those involved in its development are experts in this field and constantly measured the effects of the program on the anticipated needs of the automotive industry.

SEX EQUITY

All materials produced within this curriculum will promote sex equity and follow the guidelines established by the Equity Consultant.

A. AIR POLLUTION

1. Sources of air pollution.
2. Industrial pollution.
3. Natural pollution.
4. Automobile pollution (crankcase-fuel system-exhaust).

B. POSITIVE CRANKCASE VENTILATION SYSTEM (PCV)

1. Purpose - prevents emission of blow-by gases into atmosphere.
2. Components, PCV valve, hose, manifold vacuum port breather, filter.
3. Closed PCV system - flow of gases.
4. Open PCV system - flow of gases.
5. PCV Valve Operation - manifold vacuum vs. spring tension, flow rate high vacuum condition, low vacuum condition.
6. PCV system affects (HC - CO) and driveability.
7. Operation tests - RPM and tester method.
8. Purpose FEC system - prevent gasoline from evaporating into atmosphere (HC).
9. Components of system. Charcoal cannister, lines, filter, ported vacuum, purge valve, vapor separator, pressure vacuum cap.
10. Operation of system - constant and variable purge system.
11. Affects - controls HC and driveability of vehicle.
12. Maintenance procedures - inspect hoses - lines - services cannister filter.

C. THERMOSTIC AIR CLEANERS (TAC)

1. Purpose of TAC systems (preheat intake air).
2. Components - Snorkel tube - vacuum motor, lines, vacuum source, temperature senser.
3. Operation of system, modes. Hot air-cold air mixing.
4. Affects - HC CO driveability and carburetor icing.
5. Maintenance Procedures. Check operation of damper assembly during warm up cycle. Test vacuum motor, etc.

D. AIR INJECTION REACTION (AIR SYSTEM)

1. Purpose - Air combustion in the exhaust manifold and operates in concert with spark control systems, leaner carburetion and engine design. Aids catalytic converter burning process.
2. Air system components - air pump, check valve, air injection manifold, bypass valve, vacuum source, hoses.
3. System servicing - pump belt, operation of bypass valve, vacuum, hoses.
4. Affects - HC - CO and has an effect on driveability, catalytic converter operation.

E. EXHAUST GAS RECIRCULATION SYSTEM (EGR)

1. Purpose of EGR system - Lower combustion temperatures thus reducing NO_x. (Oxides of nitrogen)
2. System components EGR valve, vacuum source, hoses, vacuum switch, etc., vacuum amplifier.
3. Vacuum sources differ for type of valve used, EGR system.
4. Affects - Reduces NO_x and affects driveability.
5. Operational tests - hoses - valve operation - cold and normalized engine, vacuum source.

F. SPARK CONTROL SYSTEM (SCS)

1. Purpose - to retard ignition spark and control advance of ignition spark.
2. Transmission controls - standard, automatic.
3. System components-vacuum advance diaphragm, temperature override switch, transmission switch solenoid, vacuum source.
4. Operational tests - vacuum source - vacuum advance in gear positions solenoid operation.
5. Affects - driveability and reduces HC, CO, NO_x.

G. CATALYTIC CONVERTER SYSTEMS

1. Purpose Control HC, CO, NO_x, and driveability.
2. Three way catalytic converters.
3. Pellet and monolyte types.
4. Control ECU-Electron Control Unit.
5. Protection system.
6. Effects of engine performance on converter operation.
7. Poisoned converter - leaded fuel.
8. Affects HC, CO, NO_x, and driveability.

H. CARBURETOR ADJUSTING PROCEDURES

1. Lean drop method.
2. Propane method.
3. CO method.
4. Three and four gas method - as outlined by manufacturer.

AUTOMOTIVE EMISSIONS THAT REQUIRE CONTROL

AIR POLLUTION

Air pollution has always existed in some form. Volcanoes, decaying vegetation, and evergreen trees all change the chemical composition of the air to a small degree and we can do little about it. The internal combustion automobile engine, however, contributes heavily to the air pollution problem but we can do something about this. Because of basic principles of combustion, auto emissions will always cause some air pollution problems. The challenge we face is to keep this pollution to a minimum.

HYDROCARBONS (HC)

Hydrocarbons (HC) are the primary chemical components of fossil based fuels. Gasoline is a fossil based fuel. If we could achieve "complete combustion" in the automobile engine, all the hydrocarbons would be used up; unfortunately complete combustion is not possible. Every time the fuel mixture used in the engine is not completely burned, hydrocarbons are exhausted to the atmosphere. Two primary reasons why hydrocarbons is engine misfire and "quench areas". Ouench areas are places in the combustion chamber where the ignited flame is extinguished before the fuel is totally burned. Small cavities, such as where the head gasket seals the cylinder head to the block and between the top of the piston and the first compression ring, are such areas. In a cylinder misfire, none of the raw

fuel (hydrocarbons) is burned. They are simply exhausted directly to the atmosphere. Hydrocarbon emissions in the atmosphere combine with another automobile pollutant, oxides of nitrogen (NO_x), to form photochemical smog. "Smog" has a detrimental effect on both plant and animal life. Hydrocarbons are a primary source of eye irritation associated with auto pollution.

CARBON MONOXIDE (CO)

Carbon Monoxide is an odorless, colorless, toxic gas. CO is formed in the combustion chamber when there is not enough oxygen (air) in the air/fuel mixture to burn all the fuel. This means when a "rich" air/fuel mixture is introduced into the combustion chamber, the necessary chemical action to convert oxygen (O) and carbon (C) atoms to carbon dioxide (CO_2) cannot take place.

When carbon monoxide is inhaled into the lungs it cannot be detected. Headaches, reduced alertness and even death can result if concentration is high enough.

OXIDES OF NITROGEN (NO_x)

Air is composed of approximately 78% nitrogen, 21% oxygen and 1% of other gases. In the combustion chamber, flame temperatures may reach in excess of 4500°F. At temperatures above approximately 2500°F oxides of nitrogen are formed. The formation of NO_x is, therefore, dependent on temperature. Nitrogen oxides when emitted, combine with hydrocarbon emissions and form photochemical smog. The NO_x contributes the brownish color to smog.

Another chemical action involving NO_x produces ozone. Ozone is an odorous gas and is a primary cause of the smell associated with smog. Ozone also acts as an irritant to the lungs and eyes. Ozone deteriorates rubber products and effects plant growth.

SYSTEMS USED FOR THE CONTROL OF AUTOMOTIVE EMISSIONS

POSITIVE CRANKCASE VENTILATION SYSTEM (PCV)

PURPOSE

The purpose of the PCV system is to reduce hydrocarbon emissions to the atmosphere. It also helps prevent oil dilution and sludge formation in the crankcase. This is done by directing blowby gases in the crankcase back into the combustion chamber to be consumed in the normal combustion process.

MAIN COMPONENTS

SEALED OIL FILLER CAP - Prevents escape of blowby gases to the atmosphere from around the oil filler cap during heavy acceleration.

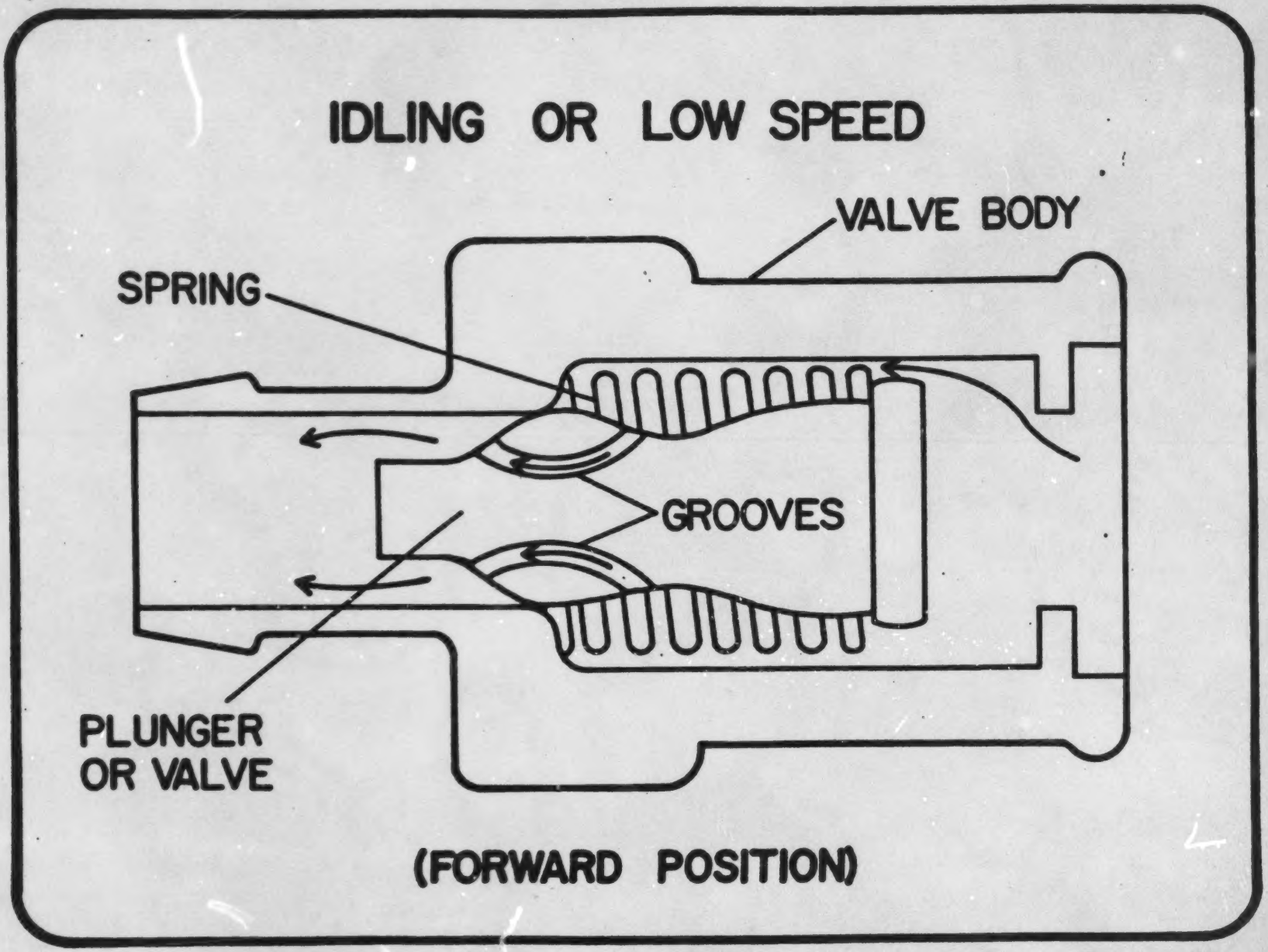
SEALED DIPSTICK CAP - Prevents escape of blowby gases to the atmosphere from around the dipstick during heavy acceleration.

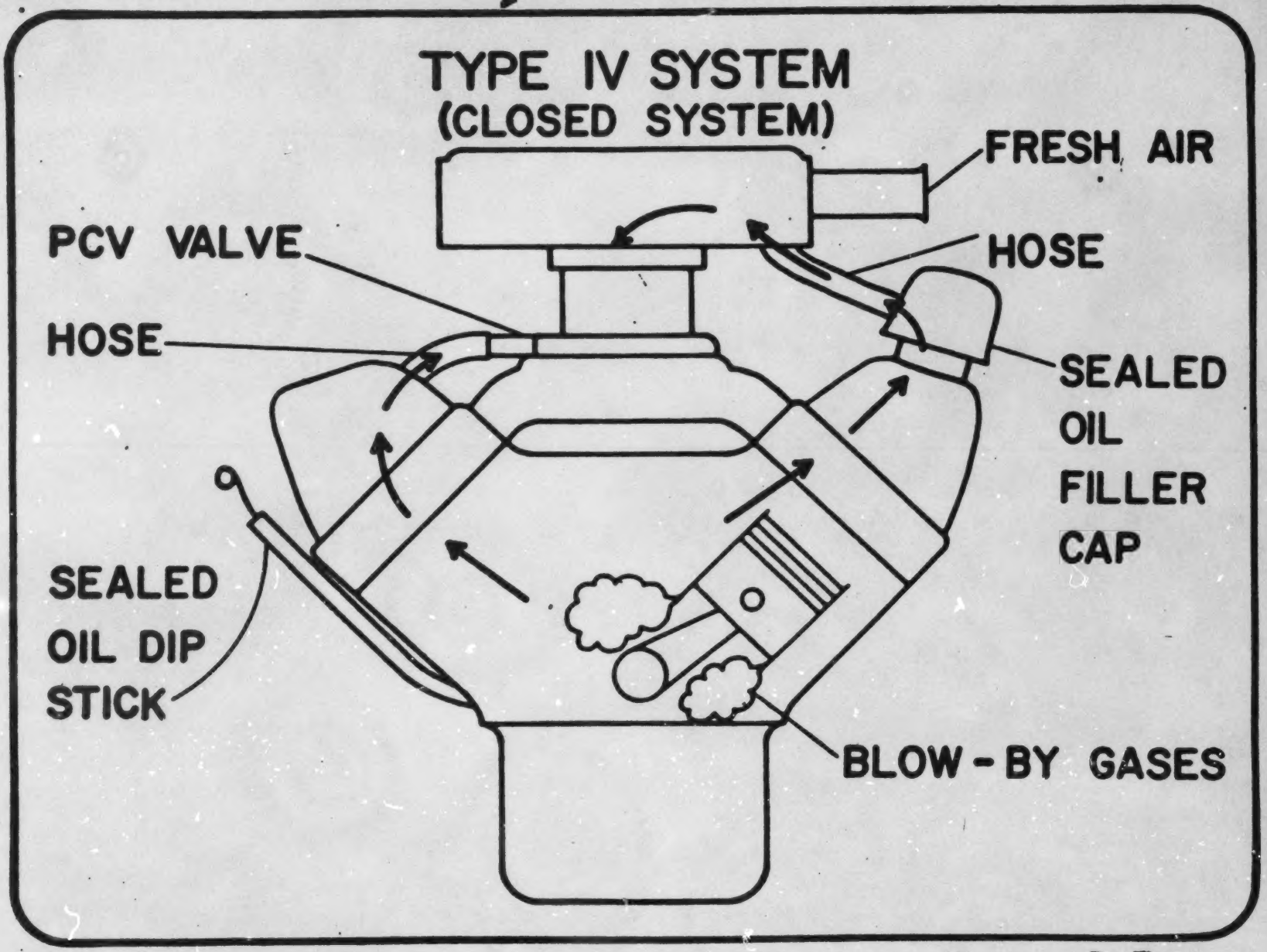
AIR INTAKE HOSE - Allows fresh air to enter the crankcase from the air cleaner

PCV VALVE - Composed of body, plunger, and spring, the PCV valve meters the flow of blowby gases from the crankcase back into the manifold by sensing intake manifold vacuum.

BASIC OPERATION

Intake manifold vacuum draws blowby gases from the crankcase into the manifold to be consumed in the combustion chamber. The PCV valve plunger prevents blowby gas flow during engine off or engine backfire conditions. Blowby gas flow is regulated by the amount of intake manifold vacuum acting on the PCV valve spring and plunger.


IDLING OR LOW SPEED
VALVE BODY
SPRING
GROOVES
PLUNGER
OR VALVE
(FORWARD POSITION)


TYPE IV SYSTEM
(CLOSED SYSTEM)
FRESH AIR
PCV VALVE
HOSE
HOSE
SEALED
OIL
FILLER
CAP
SEALED
OIL DIP
STICK
BLOW - BY GASES

THERMOSTATIC AIR CLEANER (TAC)

PURPOSE

The TAC system is designed to provide heated air to the carburetor during cold-engine conditions. By providing heated air during engine warm-up conditions, a leaner air/fuel mixture can be used, thereby, reducing hydrocarbon emissions. The system also assists in cold engine driveability and the elimination of carburetor icing.

MAIN COMPONENTS

EXHAUST MANIFOLD HEAT SHROUD - A metal shroud around the exhaust manifold that directs air flow over the exhaust manifold to preheat it.

HOT AIR PIPE - Directs air from the exhaust manifold heat shroud to the snorkel of the air cleaner.

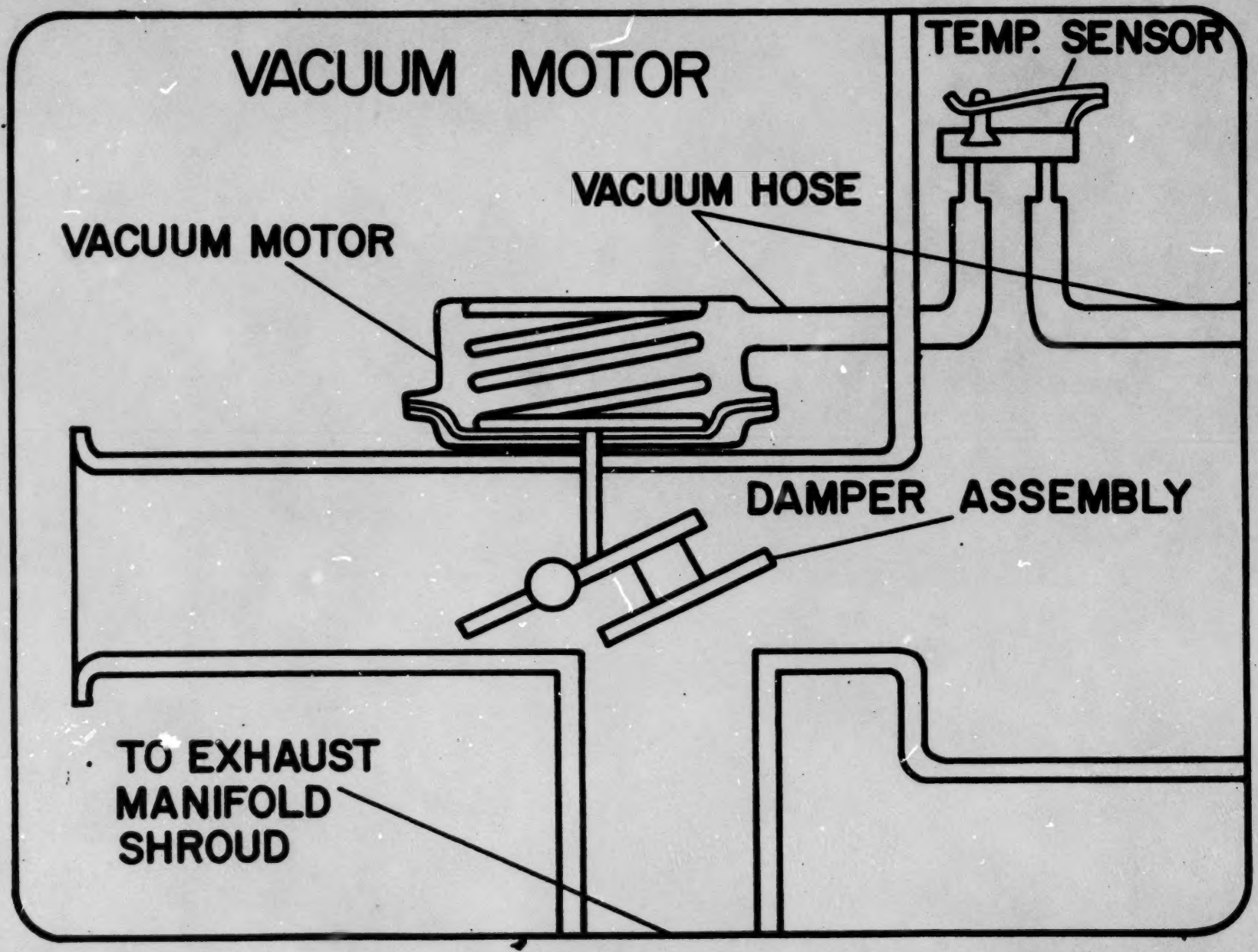
DAMPER ASSEMBLY - Regulates when and how much heated air enters the air cleaner.

VACUUM DIAPHRAGM UNIT - Controls the damper assembly. Actuated by spring pressure and intake manifold vacuum.

TEMPERATURE SENSOR - Senses incoming air temperature by means of a temperature sensing spring. The position of the spring operates a small valve that determines if vacuum is applied to vacuum diaphragm or if it is vented.

BASIC OPERATION

When the temperature sensor detects cold engine conditions, it allows intake manifold vacuum to reach the vacuum diaphragm unit. When the vacuum diaphragm receives a vacuum signal, it opens the damper assembly to allow exhaust manifold heated air to enter system. As temperature of incoming air reaches approximately 100°F, the temperature sensor bleeds off vacuum to the diaphragm unit closing the system to heated air allowing only cooler engine compartment air to enter.



THERMOSTATIC AIR CLEANER

22

23

AIR INJECTION SYSTEM (AIR)

PURPOSE

The purpose of the air injection system is to supply additional oxygen (air) at the exhaust ports near the exhaust valves to extend the combustion process into the exhaust system. This reduces the unburned hydrocarbon and carbon monoxide emissions.

MAIN COMPONENTS

AIR PUMP - Supplies filtered low pressure air to the system.

DIVERTER VALVE - Diverts air pump output to atmosphere during deceleration to prevent backfire and has a built-in pressure relief valve to protect the system.

CHECK VALVE - Prevents hot exhaust gases from backing up into the hoses and pump.

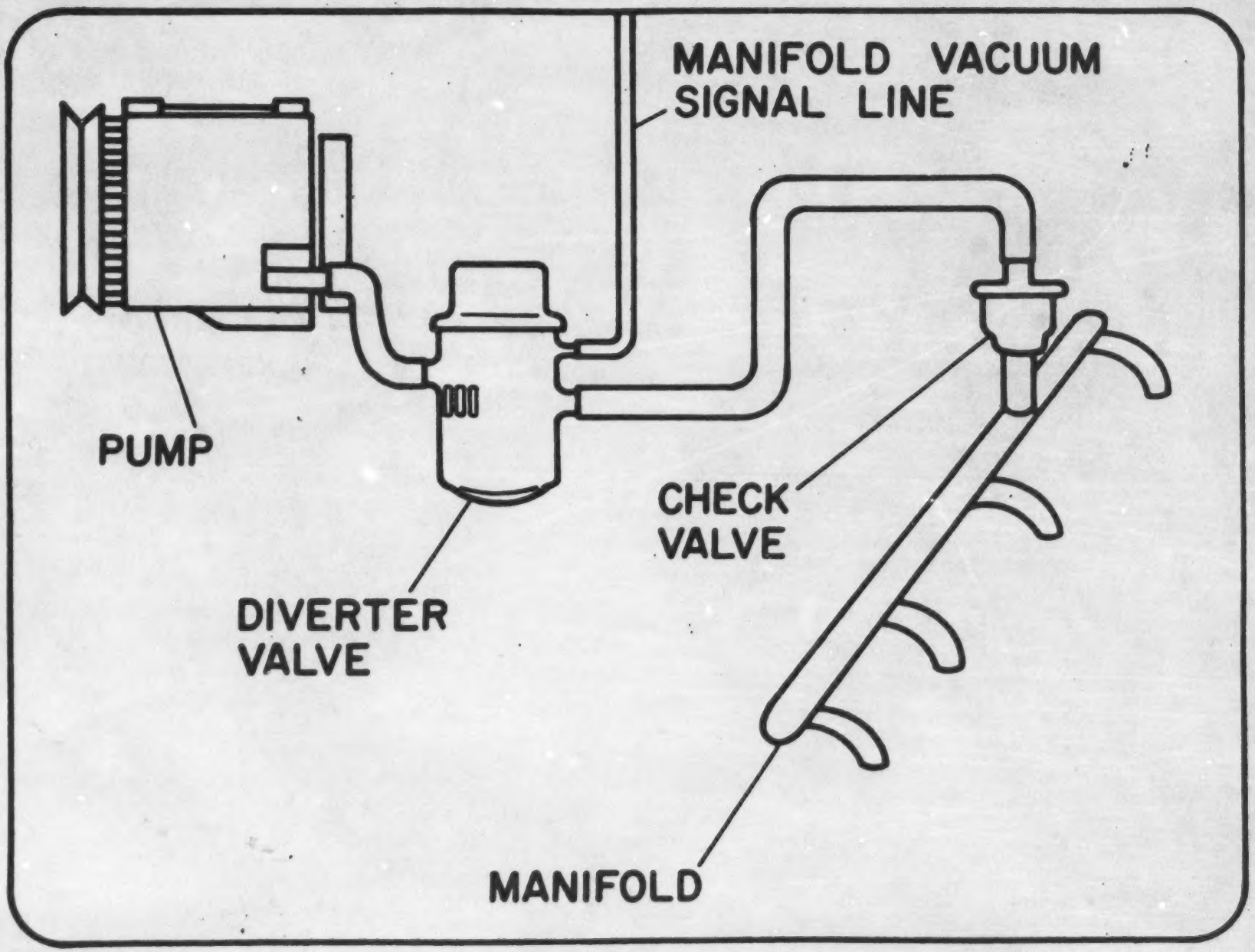
AIR MANIFOLD - Distributes air to each cylinder.

AIR NOZZLES - Injects air to each exhaust passage near the exhaust valves.

MANIFOLD VACUUM SIGNAL LINE - Senses manifold vacuum to actuate the diverter valve.

BASIC OPERATION

During normal operating conditions the air pump supplies air to the diverter valve which then passes the air on to the air nozzles for injection into the exhaust manifold. There the hot exhausted gases receive the fresh oxygen charge and undergo further combustion. During deceleration there is high intake manifold vacuum and an excessively rich fuel mixture. If fresh oxygen were supplied to these exhaust gases, reignition and engine backfire could result. The diverted valve senses the high intake manifold vacuum and vents air from the pump to the atmosphere.



26

AIR INJECTION REACTION

27

EVAPORATIVE EMISSION SYSTEM

PURPOSE

The purpose of the evaporative emission control system is to control the release of hydrocarbons (HC) to the atmosphere that results from raw fuel vapors escaping from the fuel tank and carburetor vents.

MAIN COMPONENTS

FUEL TANK - A sealed unit for storing the fuel that has a built-in air space to allow for fuel expansion due to temperature increases.

FUEL TANK FILLER CAP - Seals the fuel tank and acts as a pressure relief valve to protect tank from excessive pressure or vacuum.

VAPOR VENT LINES - Allows vapors to escape from the fuel tank and pass to a vapor - liquid separator.

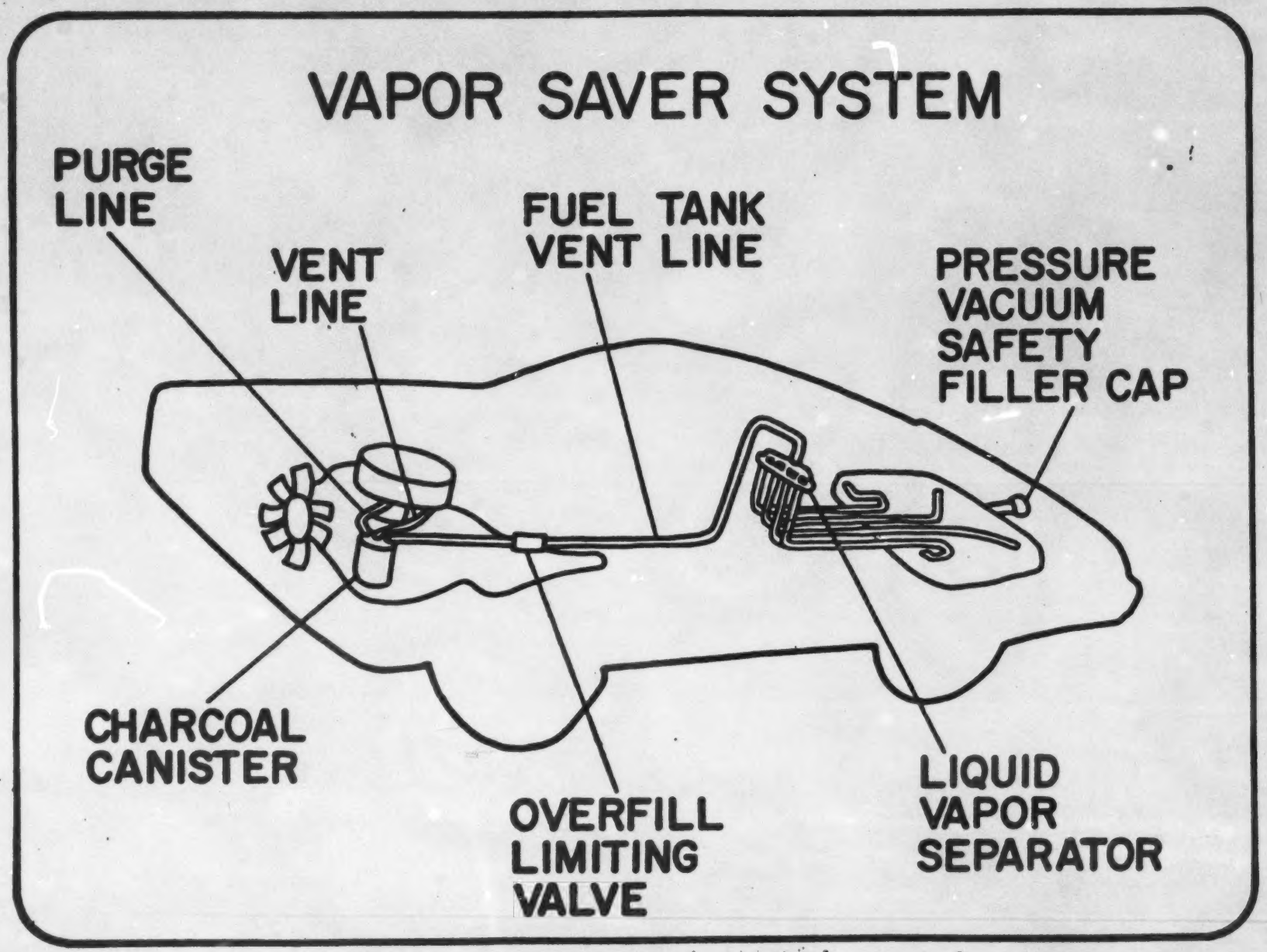
VAPOR-LIQUID SEPARATOR - Prevents passage of liquid fuel to the charcoal canister by means of either a float valve that seals the outlet when liquid fuel enters or by means of standpipes. Standpipes are set at different heights to allow liquid fuel to return to the tank and only vapors to escape.

CHARCOAL CANISTER - Contains activated charcoal that traps and stores fuel vapors. When the canister is purged with fresh air the fuel vapors are removed and vented to the carburetor.

PURGE LINE - Allows passage of fuel vapors from the charcoal canister to the carburetor or air cleaner when the engine is running.

BASIC OPERATION

When the fuel tank is full and subjected to an increase in temperature, the fuel expands and is taken up in the built-in air space. Vapors are released, they pass through the vent lines to the vapor-liquid separator which allows the vapors to pass through, but prevents any liquid fuel from passing. The vapors travel to the activated charcoal canister where they are trapped and stored. When the engine is started, the canister is purged via a purge line that runs to the carburetor or air cleaner.



FUEL EVAPORATION CONTROL (FEC)

EXHAUST GAS RECIRCULATION SYSTEM (EGR)

PURPOSE

The purpose of the exhaust gas recirculation system is to supply, in the proper proportion, inert exhaust gas to the air-fuel mixture in the intake manifold. This dilution of the air-fuel mixture reduces peak flame temperatures during combustion and reduces the amount of oxides of nitrogen (NO_x) in the exhaust.

MAIN COMPONENTS

EGR VALVE - Meters or shuts off exhaust gas flow to the air-fuel side of the intake manifold.

INTAKE MANIFOLD - Contains specially cast exhaust passages that connect to the intake side of the manifold through the EGR valve.

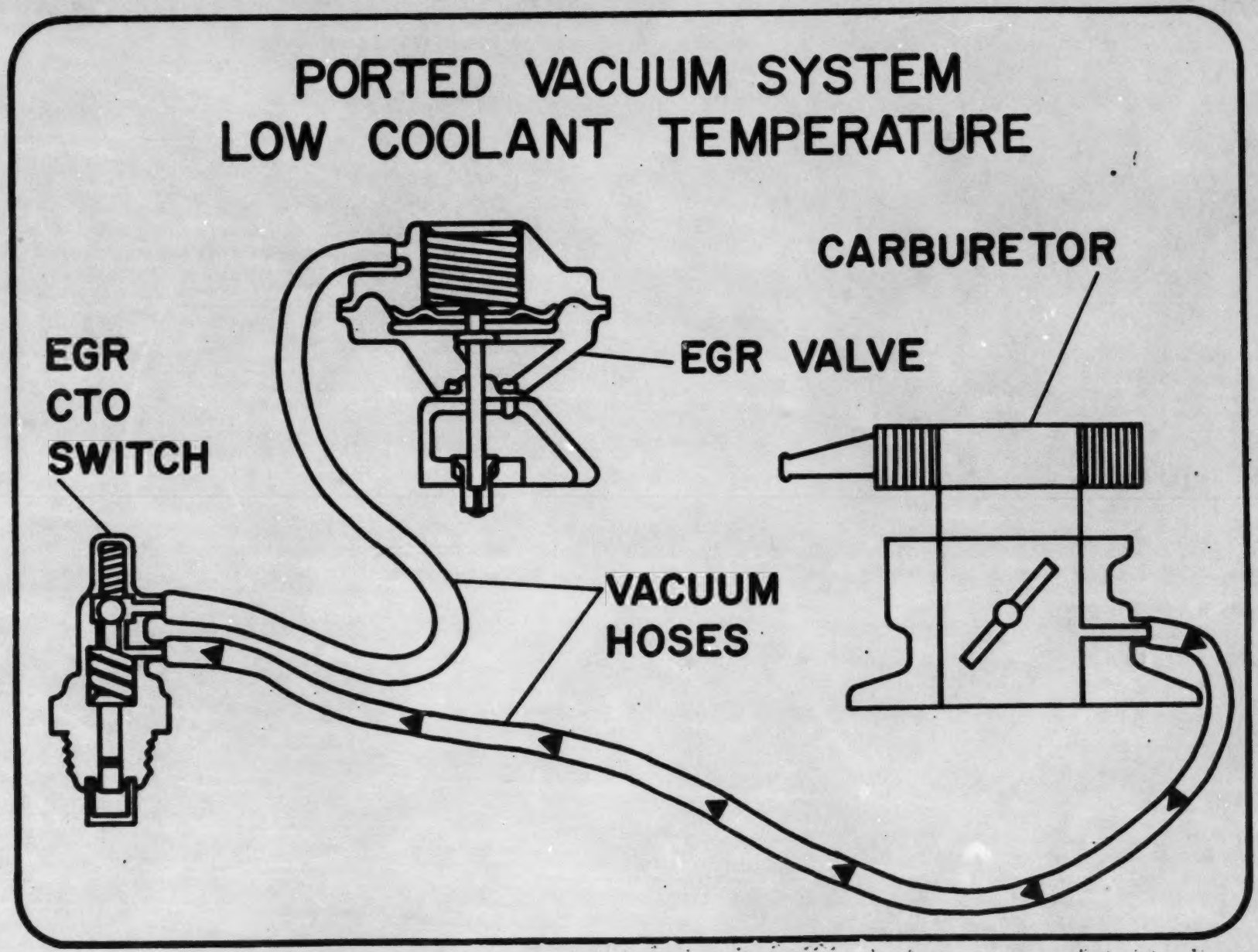
CARBURETOR SIGNAL PORT - (on ported vacuum controlled EGR) - Located in the carburetor throttle body to sense manifold vacuum and control the EGR valve.

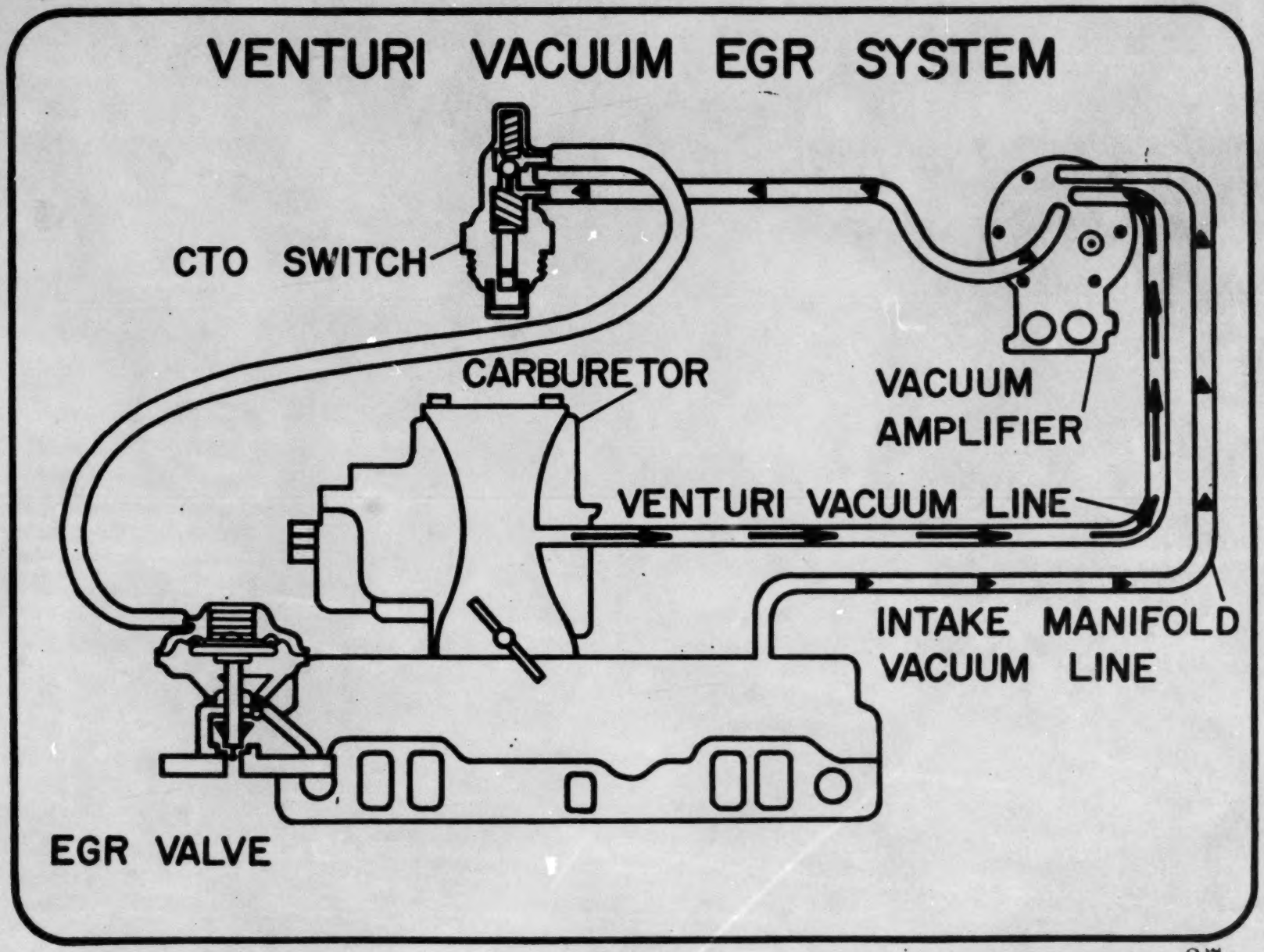
VENTURI VACUUM SIGNAL TAP - (on Venturi Vacuum controlled EGR) - Located on carburetor throat to sense venturi vacuum signal. This signal is transmitted through a vacuum amplifier to control manifold vacuum to regulate EGR valve.

TEMPERATURE CONTROLLED VACUUM VALVE - Prevents vacuum from reaching and operating the EGR valve until radiator top tank temperature reaches approximately 16°C (60°F).

BASIC OPERATION

In order for the EGR system to operate, a manifold vacuum signal must reach the EGR valve. Vacuum can be sensed and directed to the EGR valve between idle and full throttle engine operation. The ECR system will not operate at idle or full throttle - only between these two conditions. However, a vacuum signal cannot reach the EGR valve under any conditions until the radiator top tank temperature or engine coolant temperature has reached approximately 60°F. This assures good cold engine driveability. When in operation, the EGR system will divert a regulated amount of exhausted gases from the exhaust manifold back into the intake manifold to be mixed with the fresh air-fuel charge. This process reduces combustion temperatures and helps eliminate oxides of nitrogen (NO_x) from auto emissions.


PORTED VACUUM SYSTEM
LOW COOLANT TEMPERATURE
CARBURETOR
EGR VALVE
EGR
CTO
SWITCH
VACUUM
HOSES


VENTURI VACUUM EGR SYSTEM
CTO SWITCH
CARBURETOR
VACUUM AMPLIFIER
VENTURI VACUUM LINE
INTAKE MANIFOLD VACUUM LINE
EGR VALVE

SPARK CONTROL

PURPOSE

The purpose of the spark control system is to control the advance and retard of the ignition spark to improve combustion and reduce the formation of Hydrocarbons (HC) and Oxides of Nitrogen (NO_x) during varying engine operations.

MAIN COMPONENTS

TEMPERATURE SWITCH - Senses cooling system temperature and allows vacuum advance only when temperature is below approximately 93°F (33°C).

TIME RELAY - Allows vacuum advance for approximately 20 seconds after the ignition is started. After which vacuum through the vacuum advance solenoid is prevented.

TRANSMISSION SWITCH - Prevents vacuum advance in all gears except high gear.

IDLE STOP SOLENOID - Allows the throttle valves to close completely when the ignition switch is turned off. Prevents "dieseling".

VACUUM ADVANCE SOLENOID VALVE - A two-position valve allowing vacuum to reach the distributor advance unit or venting air preventing vacuum advance.

BASIC OPERATION

The spark control system operates to allow vacuum advance for the first 20 seconds after turning on the ignition, while the coolant temperature is under 93°F (33°C), or when the transmission is in high gear. At other times, the spark is in retard position which increases exhaust gas temperature, promoting additional burning of hydrocarbons (HC) in the exhaust manifold. Retarded spark will also lower peak combustion temperature (by igniting spark later in the cycle) thereby reducing oxides of nitrogen (NO_x) formation.

Some manufacturers use the following individual components on certain engines to control spark advance.

FORD DUAL DIAPHRAGM - This vacuum unit has a movable advance diaphragm which allows the spark to be retarded at idle and advance normally at port throttle.

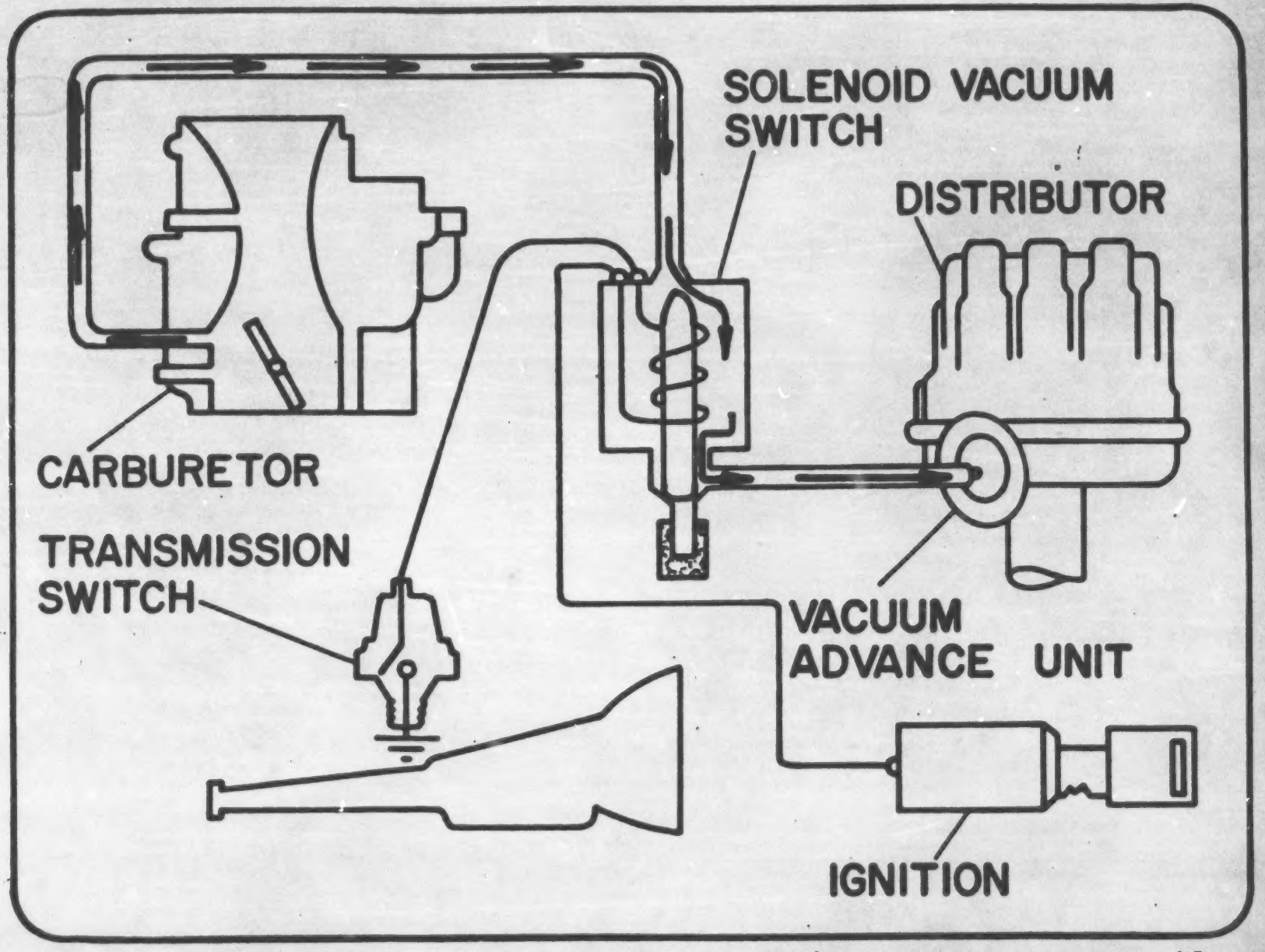
CHRYSLER DISTRIBUTORS - The Chrysler Corporation has used two different types of vacuum advance units in recent years. One uses an electric solenoid that retards the spark any time the throttle is closed. The other unit advances the timing 7 1/2° while the engine is being cranked, to allow better starting.

COMBINED EMISSION CONTROL (CEC) - A valve used by GM to control spark advance and also to momentarily hold the throttle open on deceleration for better HC emission levels. It consists of a solenoid mounted on the carburetor near the throttle.

ORIFICE SPARK ADVANCE CONTROL (OSAC) - This system is now used on all Chrysler products. Its function is to delay vacuum advance for approximately 30-45 seconds under normal engine temperatures. When the engine air cleaner temperature is below 50°F, vacuum will flow through the valve unrestricted. The valve is mounted in the air cleaner assembly.

SPARK DELAYS - Ford has used a number of spark delay valves operating similar to Chrysler's OSAC valve. This delay serves to lower HC emissions by not allowing full vacuum advance until the vehicle has been cruising for 7-20 seconds. The spark delays used by Ford do not contain a cold engine bypass system. The spark delay valves are normally found mounted in the vacuum line near the distributor.

ELECTRONIC SPARK CONTROL (ESC) - Operates similar to the temperature switch discussed in the main components of the spark control system. However, the ESC uses an electrical signal from a temperature switch mounted in the left front door pillar in some 75-76 Fords to activate an amplifier which in turn supplies the signal to the vacuum advance.



41

42

SPARK CONTROL SYSTEM (SCS)

CATALYTIC CONVERTER SYSTEM

PURPOSE

Catalytic converter systems reduce the amount of Hydrocarbons (HC) and Carbon Monoxide (CO) gas in automobile emissions by providing an additional area for exhaust gases to oxidize or burn. This is accomplished by using a chemical catalyst to speed up the oxidizing process.

MAIN COMPONENTS

OUTER SHELL - Shaped much like a muffler, the outer shell of the catalytic converter is made of stainless steel to increase durability and rust resistance.

MONOLITH ELEMENT - Used on monolith design converters, the monolith element is a honeycomb of small ceramic passageways. A very thin layer of platinum and palladium is used to cover the ceramic element. The entire element is surrounded by a stainless steel mesh for protection.

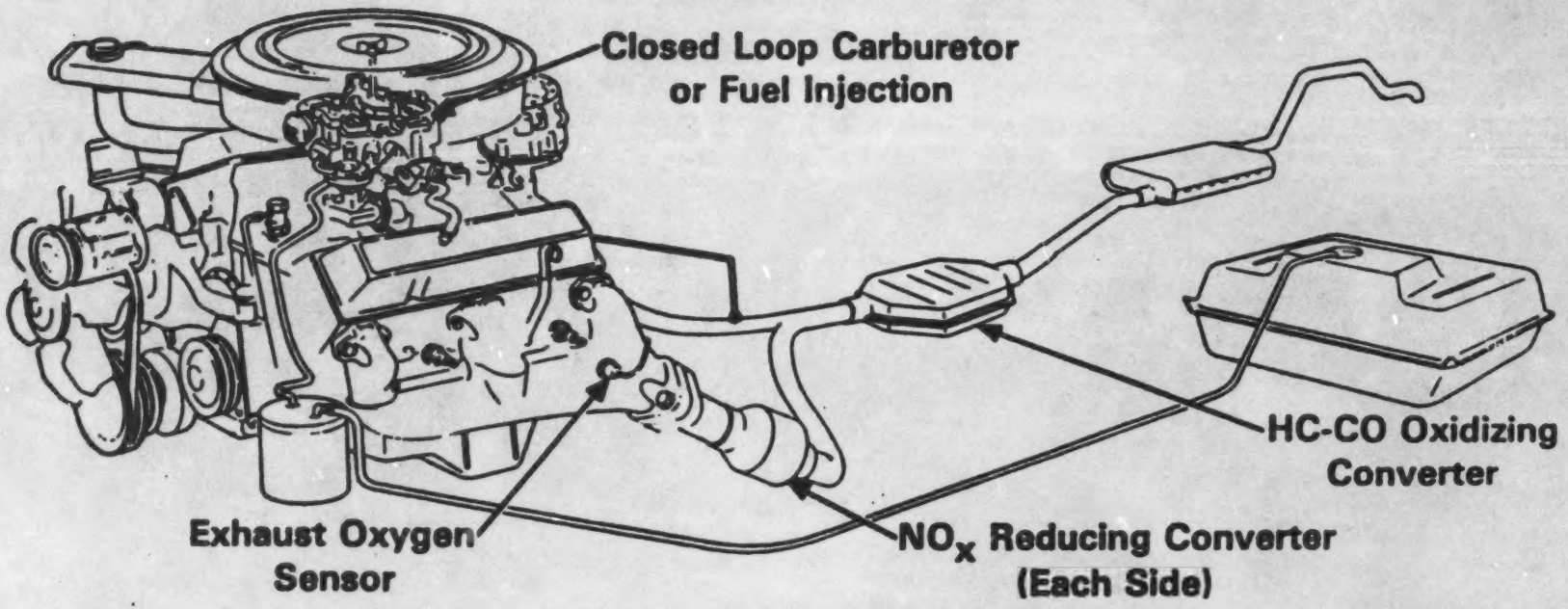
ALUMINUM OXIDE PELLETS - Used on pellet designed converters, a bed of Aluminum Oxide pellets 1/8" - 3/16" diameter are coated with a thin layer of platinum and palladium. The exhaust gas is directed to flow through these pellets.

PLATINUM AND PALLADIUM - Common elements in both the monolith and pellet design converters are the two noble metals, platinum and palladium, used as catalytic agents. (A catalyst is a substance that is used to speed up a chemical reaction). Both types of converters use approximately 70% platinum and 30% palladium in the thin film covering their interior elements.

BASIC OPERATION

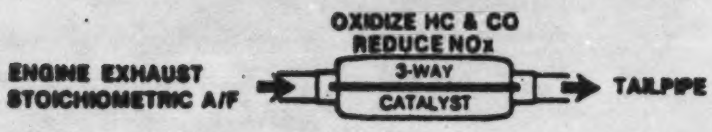
As exhausted gas leaves the manifold it enters the catalytic converter. There the gas is directed to flow over the interior monolith or pellets covered by the catalytic agents, platinum and palladium. When this happens, the exhaust gases increase their temperatures and continue to oxidize, removing hydrocarbon (HC) and carbon monoxide (CO) emissions from the exhaust before it enters the muffler. As the heat developed in the catalytic converters is very high, auto manufacturers are devising various methods of control and insulation to insure it's safe operation.

Dual Catalyst System

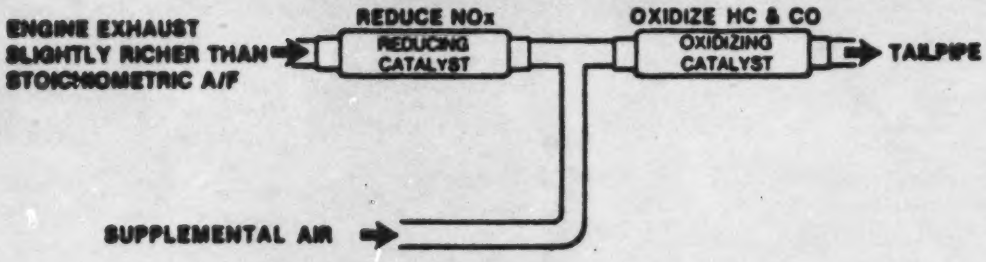


-31-

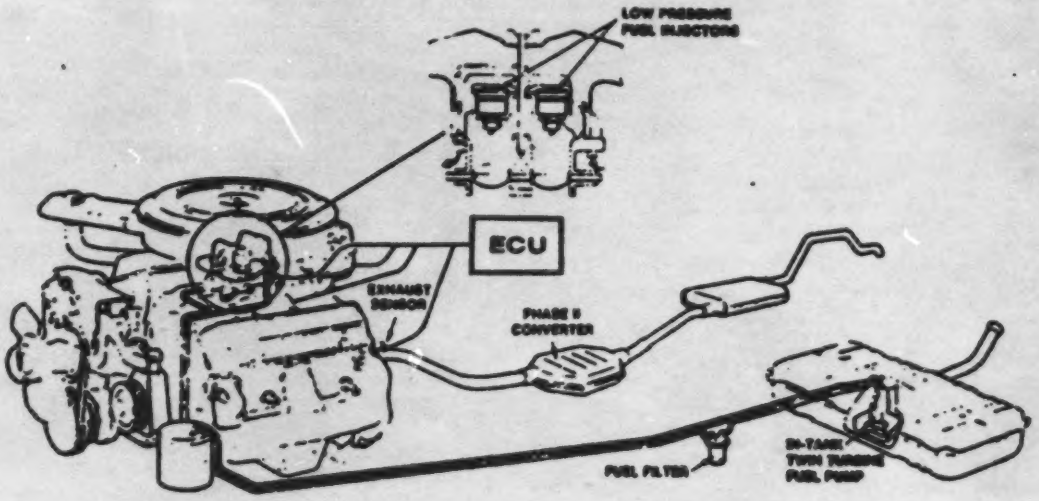
THREE-WAY CONVERTER SYSTEM



DUAL CONVERTER SYSTEM

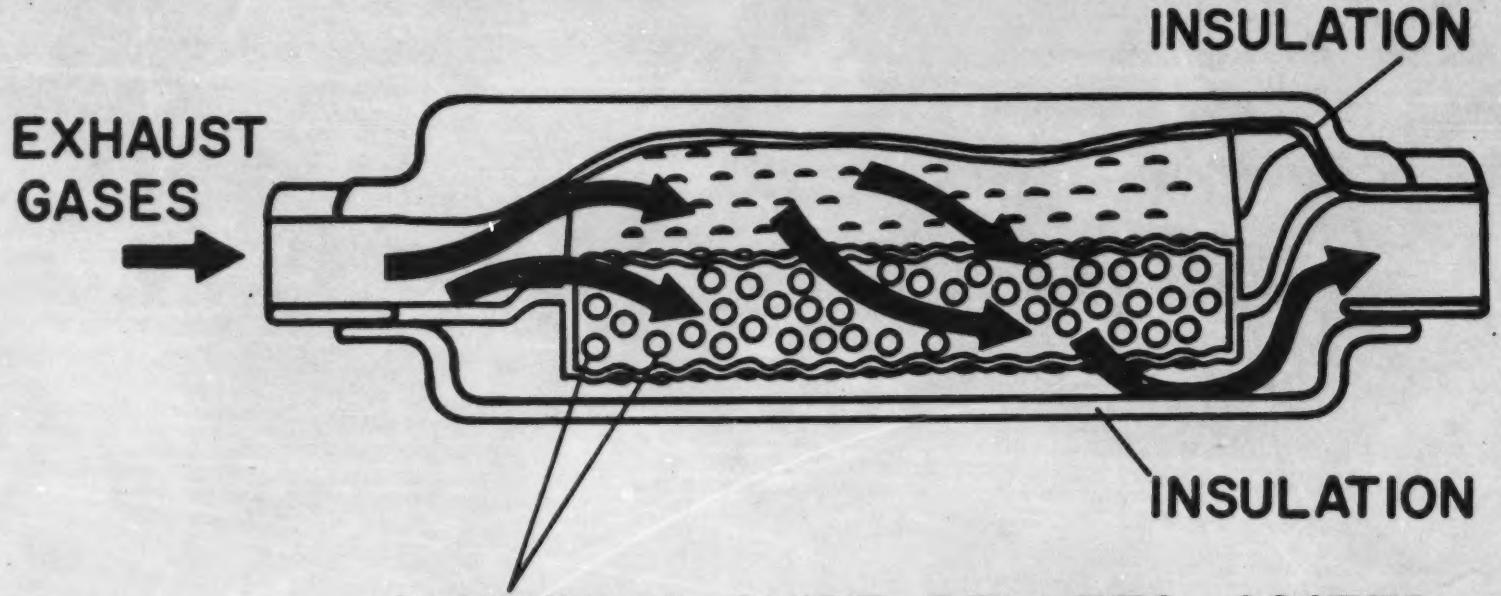


THROTTLE BODY INJECTION WITH CLOSED LOOP A/F CONTROL

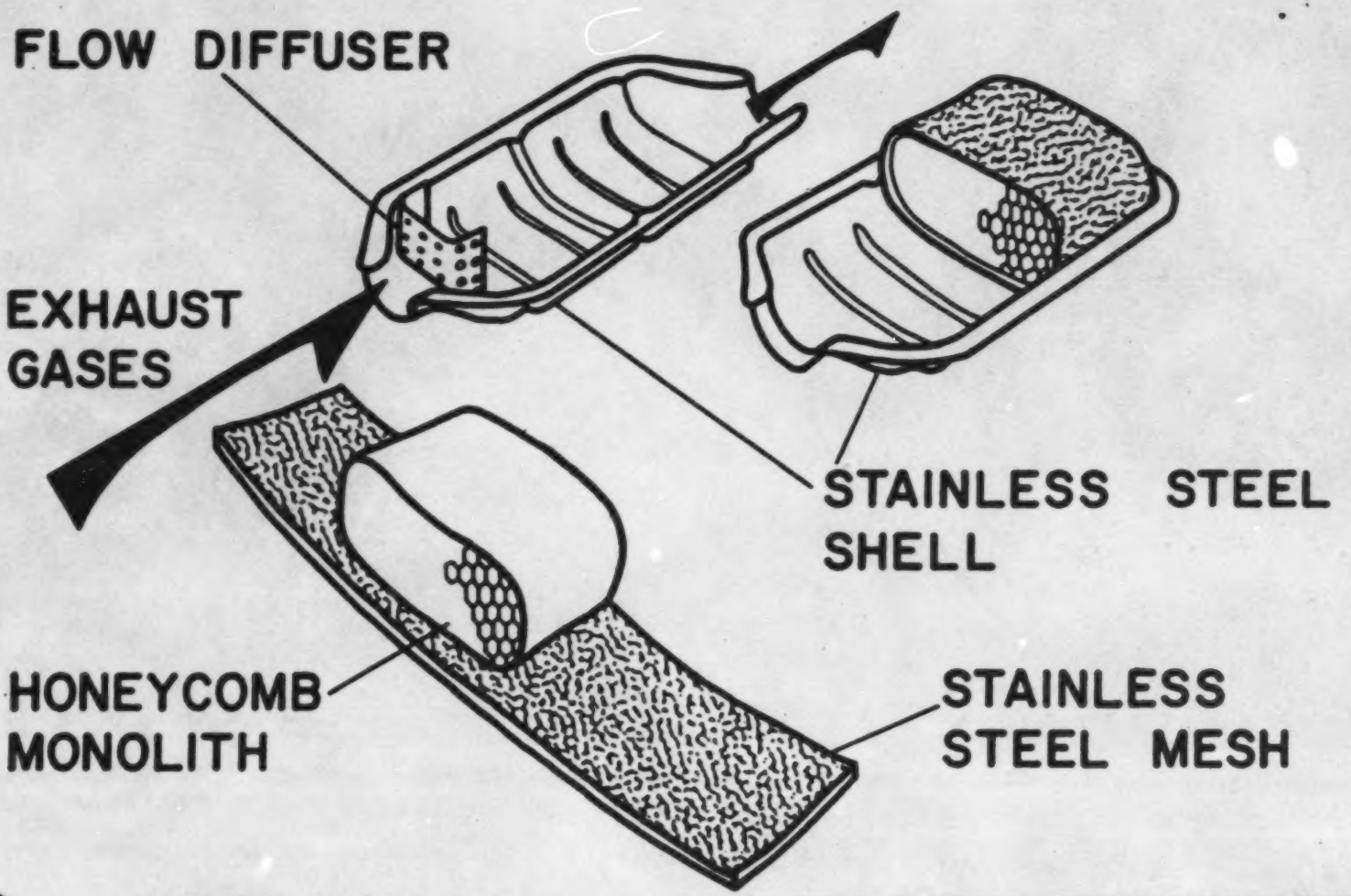


48

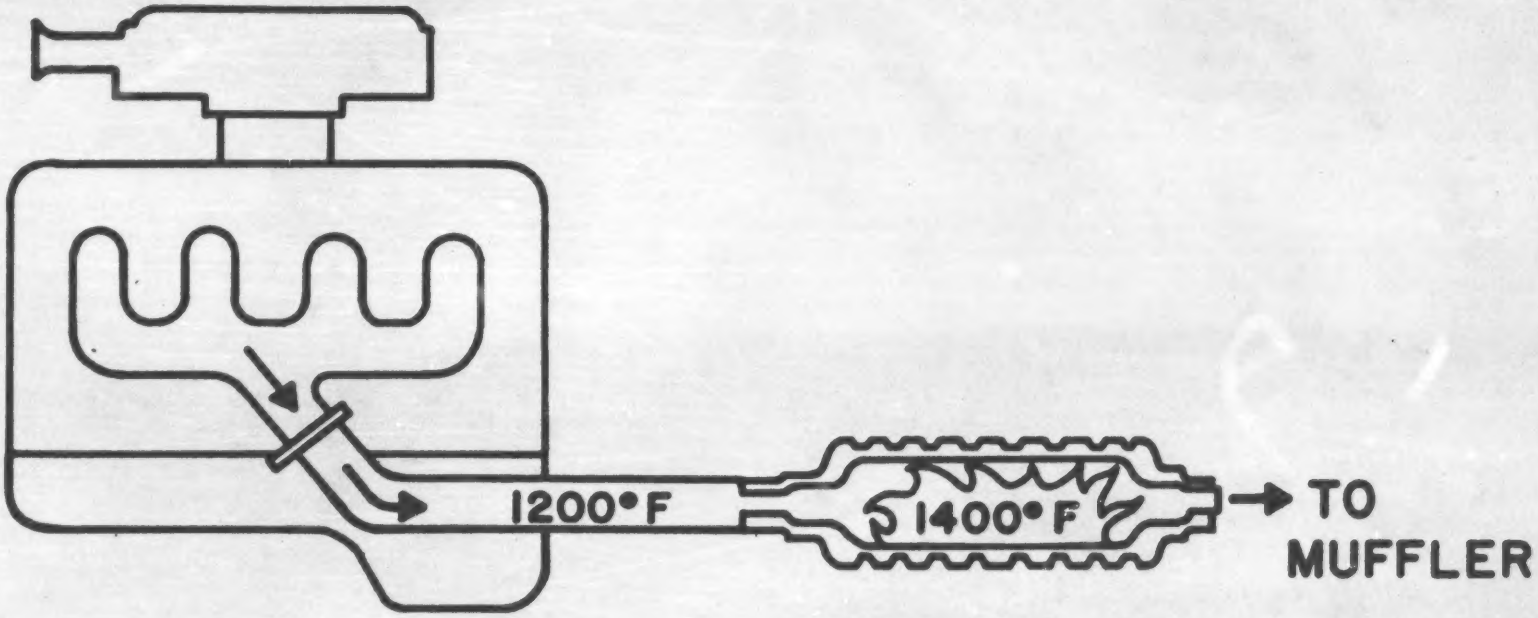
EXHAUST GAS FLOW-THRU PELLET-STYLE CATALYTIC CONVERTER



MONOLITH CONVERTER



SECONDARY COMBUSTION OR BURNING OCCURS IN THE CATALYTIC CONVERTER



TWO AND FOUR GAS EMISSION ANALYZERS

EXPLANATION OF GASES

AND

DIAGNOSTIC USE

General: The primary function of an emission analyzer is to measure the relative amounts of a running engine's main exhaust gas components. The percentages of these combustion products (most of which pollute the air we breathe) give important diagnostic clues to engine inefficiencies which affect performance and waste fuel. The two key undesirables are hydrocarbond (HC) and carbon monoxide (CO).

TWO GAS ANALYZERS MEASURE HYDROCARBONS AND CARBON MONOXIDE:

HYDROCARBONS (HC) are unburned or partly-burned fuel. High levels of them (measured as parts per million - ppm) in the exhaust gas are often related to problems in the ignition system. Fouled plugs or ignition wires, improper timing or dwell, vacuum leaks or incorrect air/fuel ratios all can cause improper combustion and high HC readings.

CARBON MONOXIDE (CO) is formed when there is not enough oxygen present during combustion. High levels of it (measured as a percentage of the exhaust gas) can be caused by a too-rich fuel mixture, low idle speed, incorrect float levels and a faulty air filter, PCV valve or carburetor.

CATALYTIC CONVERTERS NECESSITATE FOUR GAS ANALYSIS:

Beginning with the 1975 models, new vehicles have been factory-equipped with catalytic converters which chemically decrease the amount of HC and CO emitted from the exhaust pipe. The efficiency of these catalytic converters on late model cars has increased to the point where it is no longer possible to accurately detect high HC and CO levels that are diagnostic clues to engine problems. For this reason, the capability to measure two additional gases, carbon dioxide (CO_2) and oxygen (O_2), is required to diagnose the condition of vehicles beginning with model year 1975.

FOUR-GAS ANALYZERS MEASURE HC AND CO PLUS CARBON DIOXIDE (CO_2) and OXYGEN (O_2):

CARBON DIOXIDE (CO_2) - Measured as a percentage of the exhaust gas, the amount of CO_2 is an important diagnostic clue to the efficiency of the combustion process. Carbon MONoxide (1 part carbon to only 1 part oxygen) is the result of TOO LITTLE oxygen in the combustion process: carbon DIoxide (1 part carb on to TWO parts oxygen) is the result of more perfect combustion. The greater the percentage of CO_2 in the exhaust gas, the more efficiently the engine is running. 13 - 15% is considered ideal, with HC and CO at or near zero and oxygen in the 1.5% range.

OXYGEN (O_2) - The level of oxygen in the exhaust gas (measured as percent) indicates the accuracy of the carburetor setting. If oxygen content is measured as the air/fuel ratio is adjusted from rich to lean (or vice versa), a step jump in the reading of at least 0.5% shows the crossover.

point from too rich to too lean. O_2 measurement is also useful in detecting vacuum leaks and ignition problems causing misfire. Oxygen in the 1.5% range is considered ideal, with HC and CO at or near zero and CO_2 in the 13 - 15% range.

RECAP - USING CARBON DIOXIDE AND OXYGEN ANALYSIS FOR ENGINE DIAGNOSTICS

1. Particularly helpful for vehicles:
   a. With catalytic converters.
   b. With computer controlled engines that also use 3-way catalysts and air management systems.
2. Permit determination of combustion efficiency and correct carburetor settings.
3. Air/Fuel ratio can be determined by adding CO and CO_2 measurements and using HTS 4-gas Conversion Charts.
   a. Replace lean drop or propane (tricky and time-consuming) methods of carburetion adjustment.
4. Ideal: HC and CO at or near zero
   a. CO_2 in 13 - 15% range
      O_2 in 1 - 2 % range
5. Four-gas analysis permits fine tuning for low emissions and maximum fuel economy.

DIAGNOSTIC RANGE OF AUTOSENSE 4-GAS ANALYZER INCLUDES:

- Emission control devices
- Fouled or malfunctioning spark plugs
- Cracked or carbon tracked distributor cap
- Float level problems
- Air pump function
- Leaking intake manifolds
- Vacuum Leaks
- Carburetor adjustments
- PCV valve test
- Choke problems
- EGR malfunctions
- Valve train problems
- Engine mechanical malfunctions
- Heat riser and exhaust restriction problems
- Carburetor circuit testing
- Primary ignition problems
- Secondary ignition problems
- CO leakage
- Overall engine efficiency
- Computer controlled component function

Excessive HC Emissions: Other Symptoms Likely to Be Present with Each General Problem Area

	General Problem Area	Other Symptoms Likely to Be Present
most likely cause ↓	Ignition System Malfunction	1. *HC reading greater than 1000 ppm* 2. *Normal CO reading 3. Rough idle 4. Steady misfire
	Ignition Timing Defects	1. HC reading in 300-900 ppm range 2. Normal CO readings 3. Usually no misfire observed 4. Possible pinging 5. Possible rough idle
	Vacuum (Air) Leaks	1. *HC reading higher than normal - possibly wavering 2. *Very low CO reading 3. Rough idle or misfire (degree?) 4. Possible hissing sound
	EGR System Malfunction	1. *HC reading higher than normal - possibly wavering 2. *Low or normal CO reading 3. Lower than normal intake manifold vacuum reading 4. Possible rough idle or misfire
	Lean Misfire	1. *HC reading higher than normal - possibly wavering 2. *Very low CO reading 3. Rough idle 4. No other air leaks can be detected
least likely cause	Mechanical Defects in Engine	1. *HC reading higher than normal 2. Possible misfire 3. Possible mechanical noises - poor performance 4. Possible excessive smoke in exhaust

*Note: Analyzer readings for catalytic converter equipped vehicles will be slightly lower.

Excessive CO Emissions: Other Symptoms Likely to Be Present with Each General Problem Area

	General Problem Area	Other Symptoms Likely to Be Present
Simplest ↑	Air Intake System Problems	1. CO reading greater than state or manufacturers' standards 2. HC reading slightly higher than normal 3. Possible very smooth idle 4. Possible poor fuel economy 5. Possible black smoke present in exhaust 6. "Rotten Egg" odor
	Improper Carburetor Idle Mixture or Idle Speed Adjustment	1. CO reading greater than state or manufacturers' standards 2. HC reading slightly higher than normal 3. Possible very smooth idle 4. Possible poor fuel economy 5. Possible black smoke present in exhaust 6. "Rotten Egg" odor
↓ Most Complex	Internal Carburetor Problems	1. CO reading greater than state or manufacturers' standards 2. HC reading slightly higher than normal 3. Possible very smooth idle 4. Possible poor fuel economy 5. Possible black smoke present in exhaust 6. "Rotten Egg" odor

NOTE: The important point to remember in troubleshooting a CO failure is that all possibilities for a problem in the engine's air intake system are checked BEFORE a carburetor adjustment is indicated. Dwell and timing must also be correct prior to carburetor adjustments.

ADJUSTMENT PROCEDURE USING - 4 GAS ANALYZER

CATALYTIC - CONVERTER EQUIPPED VEHICLES

BEFORE PROCEEDING WITH ANY CARBURETOR ADJUSTMENTS CHECK AND CORRECT IF NECESSARY ANY IGNITION OR IGNITION TIMING PROBLEMS.

1. Disconnect evaporative emission canister from carburetor (Purge Hose).
2. Disconnect and plug hoses per vehicle emission label under hood.
3. Disconnect the air pump or asperator and plug the check valve(s).
4. Engine must be at operating temperature, choke open, and air conditioning off.
5. Connect CEA - 4 Gas, insert probe into tail pipe and connect tachometer.
6. Press automatic "Zero/Span".

IF CARBURETOR ADJUSTMENT IS REQUIRED

1. Remove limiter caps or plugs from idle adjustment screws.
2. Lightly seat mixture screws and turn each one out 2 turns.
3. Set CEA to O_2 - CO_2
4. Start engine and stabilize engine temperature.
5. Set idle RPM manufactures specification.
6. Observe O_2 (Oxygen) and CO_2 (Carbon Dioxide).

   O_2 should be between 1.0 - 2%

   CO_2 should be between 13.0 - 15%

7. Adjust fuel mixture to obtain highest CO_2 reading.

   Set CEA to HC - CO
   HC must be less than 100 PPM
   CO must be .00% or close to .00%

   If HC/CO readings are too high, correct problem before proceding with adjustment.

8. Observe O_2 reading

   If O_2 is above 2% turn mixture screws out (Rich) equally 1/8 turn.

   If O_2 is below 1% turn mixture screws in (Lean) equally 1/8 turn.

   After each adjustment reset idle RPM if required.

9. Run engine at 2000 RPM in neutral for 30-45 seconds.

   Return engine to idle and place transmission in drive (neutral for manuel shift).

10. Observe O_2 - CO_2 - HC and CO

11. If OK:

   *Disconnect CEA

   *Reconnect air pump

   *Reconnect all vacuum hoses

   *Reconnect canister

JOB OPERATIONS EMISSION PROGRAM

A. PCV SYSTEM (POSITIVE CRANKCASE VENTILATION)

1. Remove and replace PCV Valve.
2. Renew PCV vacuum hose.
3. Renew crankcase breather filter.
4. Test PCV system - RPM drop method.
5. Test PCV system - tester method.
6. Test PCV vacuum source with vacuum gauge.

B. FEC SYSTEM (FUEL EVAPORATION CONTROL)

1. Renew cannister filter.
2. Renew cannister hoses.
3. Check fuel tank cap.
4. Check purge lines for proper routing and position.
5. Check vapor separator hoses.
6. Vacuum source at cannister-at carburetor.

C. AIR SYSTEM (AIR INDUCTION REACTION)

1. Remove and replace air pump.
2. Adjust air pump belt.
3. Check air pump pressure.
4. Check operation of bypass valve.
5. Remove and replace air manifold.
6. Check valve plug and spring.
7. Remove and replace bypass valve.

D. SCS (SPARK CONTROL SYSTEM)

1. Remove and replace vacuum advance unit.
2. Remove and replace TCS.
3. Test vacuum advance unit.
4. Test vacuum at solenoid.
5. Remove and replace transmission override switch.
6. Test system operation in all gear positions.

E. EGR (EXHAUST GAS RECIRCULATION)

1. Remove and replace EGR valve.
2. Clean EGR valve and passage.
3. Check EGR vacuum source.
4. Remove and replace CTO switch.
5. Check vacuum modulator operation.
6. Test EGR valve - different types (venturi - manifold vacuum).
7. Test cooling system temperature.

F. CATALYTIC CONVERTER SYSTEM

1. Check system for exhaust leaks.
2. Remove and replace catalytic converter.
3. Service pellet type converter.
4. Remove and replace EFE valve.
5. Check operation of EFE valve.

C. CARBURETOR TESTING PROCEDURES.

1. Infrared testing HC, CO at idle.
2. Infrared testing HC, CO at 2500 RPM.
3. Adjust carburetor lean drop method.
4. Adjust carburetor propane method.
5. Adjust carb uretor CO method.
6. Adjust carburator four-gas method. HC, CO, O_2, CO_2

DEFINITION OF TERMS

AAP - Auxillary Acceleration Pump - Increases driveability by providing an extra amount of fuel to the acceleration nozzle to supplement the main accelerating pump during cold engine operation.

ABV - Air Bypass Valve - A valve used in Air Injection Systems to divert air to the atmosphere during deceleration to prevent backfire.

Automotive Emissions - Gaseous and/or particulate emissions that originate and are emitted from motor vehicles, exhaust system, crankcase, fuel tank, and carburetor.

Air-Fuel Ratio - An expression that gives the proportional mixture of air to fuel which ideally should be 15 pounds air to 1 pound fuel. i.e. 15:1

Air Guard - The name used by American Motors to describe a system that pumps air into the exhaust manifold to reduce HC and CO emissions.

AIR - Air Injection Reactor System - A system that pumps air into the exhaust manifold to reduce HC and CO emissions.

Air Pollution - The contamination of the air that results from both natures activity and mans activity.

ASV - Air Switching Valve - A valve in an air injection system that senses intake manifold vacuum and during heavy load dumps part of the air pump output to the air cleaner to reduce air injection system pressure.

Advanced Timing - A condition where the ignition timing is set to fire the spark plug before the piston reaches top dead center (B.T.D.C.).

BCDD - Boost Controlled Deceleration Device - During deceleration the BCDD valve is triggered into action by high intake manifold vacuum. The valve allows an additional source of air and fuel to enter the intake manifold during deceleration to obtain a more burnable mixture.

Definition of Terms

BID - Breakerless Inductive Discharge Ignition System - Solid state electronic ignition system that uses a trigger wheel and sensor rather than points.

BPV:BPS - Exhaust Back Pressure Transducer Valve - A device used to sense exhaust back pressure changes and control vacuum to the EGR valve in response to these changes.

Catalytic Converter - A device used in the exhaust system to reduce hydrocarbon and carbon monoxide emissions.

CCEGR - Coolant Control Exhaust Gas Recirculation - A system that prevents exhaust gas recirculation until engine coolant temperature reaches a specific value.

CCT - Computer Controlled Timing - A system that feeds input from various engine sensors into a computer. The computer then matches spark timing exactly to engine requirements throughout its full range of operation.

CDI - Capacitive Discharge Ignition - An ignition system that discharges a capacitor into the primary winding of the coil to initiate a high voltage spark at the spark plug.

CO - Carbon Monoxide - A colorless, odorless, deadly gas that results from a lack of air when hydrocarbons (HC) are burned.

CO_2 - Carbon Dioxide - A product of the complete burning of hydrocarbon fuels.

CEC - Combined Emission Control - A system very similar to most transmission-control spark (TCS) system, except the vacuum control solenoid also acts as a throttle positioner.

Combustion - The process of burning. Requires a fuel, a source of oxygen and a source of ignition such as a spark.

CSSA - Cold Start Spark Advance System - A system used on 460 CID Fords that allows full intake manifold vacuum to the distributor vacuum advance unit for better driveability when coolant temperatures are low.

CTAV - Cold Temperature Activated Vacuum - A system used by Ford to select either carburetor ported vacuum or EGR port vacuum for the distributor vacuum advance unit depending on ambient temperature.

Definition of Terms

CTO - Coolant Temperature Override Switch - A switch that prevents vacuum from reaching a component until coolant temperature reaches a certain value.

CTVS - Choke Thermal Vacuum Switch - A switch used by Oldsmobile to deny vacuum to either the front or auxillary choke vacuum breaks to slow choke opening and provide better driveability when the engine is cold.

DAD - Dual Area Diaphragm - Used by Ford in 1973. This unit sensed intake manifold vacuum and EGR vacuum signals and used these signals to achieve more desirable shift points and smoothness.

DAS - Distributor Advance Solenoid - Used by Chrysler to give a 7 1/2° spark advance while cranking the engine for easier starting.

DDD - Dual Diaphragm Distributor - A distributor vacuum advance unit that uses intake manifold for retard operation and carburetor ported vacuum for timing advance operation.

DMS - Distributor Modulator System - A speed controlled spark system used by Ford in 1970.

DRCV - Distributor Retard Control Valve - A valve used in Ford's Cold Start Spark Advance (CSSA) system that allows manifold vacuum to reach the vacuum advance unit and then keeps it there for constant vacuum advance until coolant temperature reaches 128°F. Used for increased driveability.

DSC - Dual Stage Electric Assist Choke - An electrical control switch operated heating element used by Chrysler to prevent prolonged choke operation after initial warmup.

DTVS - Distributor Thermal Vacuum Switch - A switch used by Oldsmobile to direct manifold vacuum to the distributor vacuum advance unit when coolant temperatures exceed approximately 220°F.

DV - Fuel Decel Valve - A valve used by Ford, Saab and Subaru that provides an additional air-fuel mixture during deceleration.

DVB - Delay Vacuum Bypass System - An optional system used by Ford that bypasses the spark delay valve during cold operation to improve driveability.

Definition of Terms

DVV - Distributor Vacuum Valve - A valve used by Oldsmobile that allows ported vacuum to vacuum advance unit until vacuum reaches 7-8" Hg. The valve then switches to EGR port vacuum.

ECS - Evaporation Control System - A system used to prevent the escape of gasoline vapors to the atmosphere from the fuel tank and carburetor.

EDM - Electronic Distributor Modulator - A speed controlled spark system used by Ford in 1970 and 1971.

FCO - Fuel Cutoff Valve - Used by some foreign manufacturers. Valve prevents fuel flow in carburetor when engine is shut off.

HEI - High Energy Ignition - An electronic ignition system used by General Motors.

HC - Hydrocarbons - Any compound that is made up of hydrogen (H) and carbon (C). Gasoline, diesel fuel and lubricating oil are made up of hydrocarbons.

IES - Idle Enrichment System - A system used by Chrysler that allows more fuel to enter the cylinders when the engine is cold for better driveability. As the engine warms up the normal air-fuel ratio is restored.

IMCO - Improved Combustion System - A series of engine, carburetion, and ignition modifications made by Ford to reduce exhaust emissions.

IR - Infrared Exhaust Analyzer - An instrument used to measure the unburned hydrocarbons (HC) and carbon monoxide (CO) that is discharged from a vehicle exhaust pipe.

Manifold Vacuum - The vacuum that results from the pumping action of the pistons and is felt below the carburetor throttle plates and throughout the intake manifold.

Modulator - A device that controls or regulates the intensity of a vacuum, electrical, or pressure signal.

NO_x - Oxides of Nitrogen - Different combinations of oxygen (O) and nitrogen (H) that results from high temperatures in the internal combustion engine.

OSAC - Orfice Spark Advance Control - A device used by Chrysler to apply vacuum to the vacuum advance unit over a period of time. By limiting the timing advance rate NO_x is reduced.

Definition of Terms

OTVS - Oil Thermal Vacuum Switch - A switch used by Oldsmobile to shut off vacuum to the early fuel evaporation (EFE) valve when oil temperature reaches 150°F.

Oxidize - The process of adding oxygen to an element, example, adding an oxygen (O) to carbon (C) results in an oxidized carbon atom which is CO or carbon monoxide.

Oxygen - A colorless, odorless, gas that makes up about 20% of our atmosphere and is necessary for combustion or burning to occur.

PVA - Ported Vacuum Advance - A port for a vacuum connection that is located above the idle position of the throttle plates. When the throttle plates are in idle position, there is no vacuum at the port. When the throttle is opened then a vacuum signal is available to the vacuum advance unit.

Retarded Timing - A condition where ignition timing is set to fire the spark plug before the piston reaches Top Dead Center (B.T.D.C.).

SAVM - Spark Advance Vacuum Modulator - A valve used by Oldsmobile that is sensitive to engine load and varies the vacuum signal strength and source to the distributor in response to engine load.

SCS - Speed Controlled Spark - A system used on some General Motors cars to prevent any vacuum advance from occuring until a certain speed is reached.

SDV - Spark Delay Valve - A valve in the vacuum advance hose that delays the vacuum signal to the vacuum advance unit.

SPTC - Spark Timing Control System - A dual point distributor system used by Datsun. This system uses a retarded timing for city driving and advanced timing for highway driving. The selection is controlled electrically.

TIC - Thermal Ignition Control - A device used by Chrysler that shifts the vacuum advance vacuum source from ported vacuum to manifold vacuum when coolant temperature exceeds 225°F.

TR - Thermal Reactor - A special design of exhaust manifold that retains heat and keeps the exhaust gases within it for a longer period of time to promote further oxidation or burning of hydrocarbons and carbon monoxide.

Definition of Terms

Transducer - A device that receives a signal from one system (such as exhaust back pressure) and transfers that signal to another system (such as a vacuum source).

TRS - Transmission Regulated Spark - A system used by Ford that prevents any vacuum advance from occurring until the transmission is shifted into high gear.

TVS - Thermal Vacuum Switch - A temperature sensitive switch that shifts vacuum advance vacuum sources from ported to manifold vacuum when coolant temperatures reach approximately 225°F.

Vacuum - A pressure that is less than atmospheric pressure. Vacuum is used extensively in motor vehicles for control purposes.

VBV - Vacuum Bias Valve - A valve used by Pontiac to prevent engine surge caused by the EGR system during highway cruise conditions.

VDV - Vacuum Differential Valve - A device used on the Chevette that senses intake manifold vacuum and triggers the bypass valve to dump injected air to the atmosphere during deceleration.

VDV - Vacuum Delay Valve - Used by GM to bleed ported vacuum through a small orifice to vacuum advance unit and control vacuum advance rate.

Venturi Vacuum - A weak vacuum signal that originates at the venturi of the carburetor. As engine speed increases, the venturi vacuum signal increases.

VHC - Vacuum Operated Exhaust Heat Control Valve - A vacuum operated heat riser valve used by Ford to cause exhaust flow through intake manifold crossover passage for preheating of air/fuel mixture.

VRV - Vacuum Reducer Valve - Used by GM on some models to reduce vacuum to vacuum advance unit by 1 1/2 - 3" Hg when coolant temperature is greater than 220° to reduce detonation.

VSV - Vacuum Switching Valve - An electrically controlled vacuum switching valve used by Toyota to control their emission control devices.

VTV - Vacuum Transmitting Valve - A valve used by Toyota to limit the rate of vacuum advance.

Definition of Terms

H.C. P.P.M.

Engineering team it's sole purpose is to indicate a relative quanity. For example a reading of 200 P.P.M. indicates that for every one million molecules of exhaust gas coming out of the tailpipe 200 of these molecules will be H.C.

C.O.%

(2%) two percent of C.O. reading means that for every 100 cu.ft. of exhaust emitted 2 cu. ft. will be carbon monoxide.

Air leaks in the exhaust system delute's reading lower than normal.

STOICHIO-METRIC RATIO

is the point where the theoretically chemically correct mixture of air and fuel exists needed to give complete combustion within the engine.

APPENDIX I

MOTOR VEHICLE EMISSIONS CONTROL MANUFACTURERS ABBREVIATIONS

AAP - Auxillary Acceleration Pump

ABV - Air Bypass Valve

ABPV - Air Bypass Valve

A/F Ratio - Air-Fuel Ratio

AG - "Air Guard". Air Pump System

A.I.R. - Air Injection Reactor System

A.S.V. - Air Switching Valve

BCDD - Boost Controlled Deceleration Device

BDC - Bottom Dead Center

BHP - Brake Horsepower

BID - Breakerless Inductive Discharge Ignition System

BPS - Exhaust Back Pressure Sensor

BPV - Exhaust Back Pressure Transducer Valve

C^{O} - Degrees Centigrade

CAM - Choke Air Modulator Switch

CAP - Cleaner Air Package. Chrysler first used 1966.

CAS - Cleaner Air System. Chrysler 1969.

CAT - Catalytic Converter

CCEGR - Coolant Control Exhaust Gas Recirculation

CCS - Controlled Combustion System

CCT - Computer Controlled Timing

Abbreviations

CCV	- Closed Crankcase Ventilation
CDI	- Capacitive Discharge Ignition
CEC	- Combined Emission Control
CFM	- Cubic Feet Per Minute
CID	- Cubic Inch Displacement
CO	- Carbon Monoxide
CO_2	- Carbon Dioxide
CRV	- Coasting Richer Valve
CSC	- Cold Start Cycle
CSSA	- Cold Start Spark Advance System
CTAV	- Cold Temperature Activated Vacuum
CTO	- Coolant Temperature Override
CTVS	- Choke Thermal Vacuum Switch
CV	- Check Valve
DAD	- Dual Area Diaphragm
DAS	- Distributor Advance Solenoid
DD	- Dual Distributor
DDD	- Dual Diaphragm Distributor
DDV	- Distributor Decel Valve
DMS	- Distributor Modulator System
DP	- Dashpot
DPD	- Dual Point Distributor
DRS	- Distributor Retard Solenoid
DRCV	- Distributor Retard Control Valve
DSC	- Dual Stage Electric Assist Choke

Abbreviations

DTVS	- Distributor Thermal Vacuum Switch
DV	- Fuel Decel Valve
DVCS	- Distributor Vacuum Control Switch
DVB	- Delay Vacuum By-Pass System
DVDSV	- Differential Vacuum Delay and Seperator Valve
DVV	- Distributor Vacuum Valve
DVV	- Distributor Vacuum Advance Modulator Valve
EAC	- Electric Assist Choke
ECS	- Evaporation Control System
EDM	- Electronic Distributor Modulator
EFE	- Early Fuel Evaporative System
EFI	- Electronic Fuel Injection
EGR	- Exhaust Gas Recirculation
ESC	- Electronic Spark Control
F^{O}	- Degrees Fahrenheit
FEC	- Fuel Evaporation Control System
FCO	- Fuel Cut Off Valve
FVR	- Fuel Vapor Recovery System
HAI	- Heated Air Inlet System
HEI	- High Energy Ignition System
Hg	- Mercury
HC	- Hydrocarbons
IES	- Idle Enrichment System
IMCO	- Improved Combustion System
IR	- Infrared Exhaust Analyzer

Abbreviations

ISS	- Idle Stop Solenoid
MCV	- Mixture Control Valve
MFI	- Mechanical Fuel Injection
NO_x	- Oxides of Nitrogen
OSAC	- Orfice Spark Advance Control
OTS	- Oil Temperature Switch
OTVS	- Oil Thermal Vacuum Switch
PCV	- Positive Crankcase Ventilation
PTC	- Positive Temperature Coefficient Choke Heater
PVA	- Ported Vacuum Advance
PVS	- Ported Vacuum Switch
RDV	- Retard Delay Valve
SAVM	- Spark Advance Vacuum Modulator
SCS	- Speed Controlled Spark
SCS	- Speed Control Switch
SDV	- Spark Delay Valve
SPTC	- Spark Timing Control System
S/S	- Fords Solid State Ignition System
STC	- Spark Timing Control System
TAC	- Thermostatic AIR Cleaners
TAV	- Temperature Actuated Vacuum System
TCS	- Transmission Controlled Spark
TDC	- Top Dead Center

Abbreviations

TDP - Throttle Closing Dashpot

TDR - Time Delay Relay

TIC - Thermal Ignition Control

TO - Thermal Override

TOC - Throttle Opener Control System

TPV - Throttle Poppet Valve

TP - Throttle Positioner

TR - Thermal Reactor

TRS - Transmission Regulated Spark

TVS - Thermal Vacuum Switch

TVSV - Thermostatic Vacuum Switching Valve

TVV - Thermal Vacuum Valve

VAC - Vacuum Advance Control

VAS - Vacuum Advance Solenoid

VAV - Vacuum Advance Valve

VBV - Vacuum Bias Valve

VDV - Vacuum Differential Valve

VDV - Vacuum Delay Valve

VHC - Vacuum Operated Exhaust Heat Control Valve

VIN - Vehicle Identification Number

VRV - Vacuum Reducer Valve

VSV - Vacuum Switching Valve

VTM - Vacuum Throttle Modulator

VTV - Vacuum Transmitting Valve

W/O - Without

APPENDIX II

SOURCES FOR MANUFACTURER'S EMISSIONS CONTROL MANUALS

Availability and costs of manufacturer's emissions control manuals can be obtained by written request to the following addresses. Check with your local dealers for vehicles not listed. They can provide the addresses for obtaining manuals.

1. American Motors Corporation - American Motors Corporation
   14250 Plymouth Road
   Detroit, Michigan 48232

2. Chrysler Corporation - Chrysler Corporation
   Service Department
   P. O. Box 40
   Detroit, Michigan

3. Datsun - Parker Industries, Inc.
   609 Deep Valley Drive
   Rolling Hill Estates, California 90274

4. Ford - Helm Incorporated
   P. O. Box 07150
   Detroit, Michigan 48207

5. General Motors Corporation - GMC Truck & Coach
   Division Printing, Inc.
   Department GMC
   1179 Sylvertis Road
   Pontiac, Michigan 48054

6. Honda - American Honda Motor Company Inc.
   Automobile Customer Service Dept.
   100 West Alondra Blvd.
   Gardena, California 90247
   213-327-8280

7. Toyota - Toyota Motor Sales USA, Inc.
   2055 West 190th Street
   Torrance, California 90504
   213-532-5010 - Customer Relations

8. Volkswagen - Robert Bently Incorporated
   872 Massachusetts Avenue
   Cambridge, Massachusetts 02139

APPENDIX III

PUBLIC INFORMATION MATERIALS

Get a Check-up for your Car! -
A leaflet on the need for keeping cars well maintained to cut pollution along with pointers on what can go wrong with your engine and what to do about it. Available in English and Spanish from your local ALA chapter or EPA Regional Office.

I/M Fact Sheet (MSAPC) -
A seven page "Questions and Answers" about I/M Programs.

Do you Own a Car?
A leaflet which explains pollution control systems and gives the reasons why motorists should not tamper with those devices, January 1978.

Measuring Air Quality -
A leaflet which explains the new pollutant standards index for reporting air quality in the mass media, July 1978.

Unleaded Gas . . . The Way to Go -
Describes what fuel switching is and the impact on air quality, September 1978.

What you Should Know about your Auto Emission Warranty -
June 1978.

So Your Car Failed the Emission Test -
A guide for proper maintenance for those who want to do it right.

If you Live in High-Altitude Areas -
Denver, Salt Lake City, Albuquerque, Colorado Springs--for health sake, buy a high-altitude car, December 1979.

Cleaning the Air, EPA's Program for Air Pollution Control -
A leaflet, June 1979.

Highlights of the Clean Air Act Amendments of 1977 -
April 1979.

Ozone - Its Effects and Control -
A booklet, April 1979.

Poster -
A 9 x 12 inch, blue and white poster of a family in a car, with the words "Tune-Up for Clean Air and Save Gas Too!"

The National Center for Vehicle Emissions Control and Safety - A description of their training programs and technical assistance projects. Available through EPA in Ann Arbor, Michigan or the Department of Industrial Sciences, Colorado State University, Fort Collins, Colorado.

The materials listed above are available at EPA Regional Offices - To receive copies, call your I/M Representative:

Region 1, Boston
Peter Hagerty, Air Programs - (617) 223-5630
Gail Peterson, Public Information - (617) 223-0967

Region 2, New York
Paul Truchan, Air Programs - (212) 264-2551
Herman Phillips, Public Information - (212) 264-2515

Region 3, Philadelphia
Chuck Miesse, Air Programs - (215) 597-8180
Caroline Pratt, Public Information - (215) 597-9826

Region 4, Atlanta
Ron McHenry, Air Programs - (404) 881-2864
Gordon Kenna, Public Information - (404) 881-3004

Region 5, Chicago
Carl Nash, Air Programs - (312) 886-6069
Kent Kozina, Public Information - (312) 886-6063

Region 6, Dallas
Ragan Broyles, Air Programs - (214) 767-2742
Eddie Lee, Public Information - (214) 767-2630

Region 7, Kansas City
Mickey Marshall, Air Programs - (816) 374-3791
Rowena Michaels, Public Information - (816) 374-5894

Region 8, Denver
Dale Wells, Air Programs - (303) 327-3711
Nola Cooke, Public Information - (303) 327-5927

Region 9, San Francisco
Phil Bobel, Air Programs - (415) 556-7288
Steve Drew, Public Information - (415) 556-0217

Region 10, Seattle
George Able, Air Programs - (206) 442-1226
Bob Jacobson, Public Information - (206) 442-1203